Title:

A Parametric Model of Shoulder Articulation for Virtual Assessment of Space Suit Fit

Authors:

K. Han KIM 1, Karen S. YOUNG 1, Yaritza BERNAL 2, Abhishektha BOPPANA 3
Linh Q. VU 4, Elizabeth A. BENSON 5, Sarah JARVIS 5, Sudhakar L. RAJULU 6

Author Affiliations:

1 Lockheed Martin Corp.
2 Universities Space Research Association
3 National Space Biomedical Research Institute
4 Geologics Corp.
5 MEI Technologies, Inc.
6 NASA – Anthropometry and Biomechanics Facility

Corresponding Author:

karen.s.young@nasa.gov
2101 NASA Parkway JSC-SK, Houston, TX 77058, USA

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Abstract:

Shoulder injury is one of the most severe risks that have the potential to impair crewmembers' performance and health in long duration space flight. Overall, 64% of crewmembers experience shoulder pain after extra-vehicular training in a space suit, and 14% of symptomatic crewmembers require surgical repair (Williams & Johnson, 2003).

Suboptimal suit fit, in particular at the shoulder region, has been identified as one of the predominant risk factors. However, traditional suit fit assessments and laser scans represent only a single person's data, and thus may not be generalized across wide variations of body shapes and poses.

The aim of this work is to develop a software tool based on a statistical analysis of a large dataset of crewmember body shapes. This tool can accurately predict the skin deformation and shape variations for any body size and shoulder pose for a target population, from which the geometry can be exported and evaluated against suit models in commercial CAD software.

A preliminary software tool was developed by statistically analyzing 150 body shapes matched with body dimension ranges specified in the Human-Systems Integration Requirements of NASA ("baseline model"). Further, the baseline model was incorporated with shoulder joint articulation ("articulation model"), using additional subjects scanned in a variety of shoulder poses across a pre-specified range of motion. Scan data was cleaned and aligned using body landmarks. The skin

deformation patterns were dimensionally reduced and the co-variation with shoulder angles was analyzed.

A software tool is currently in development and will be presented in the final proceeding. This tool would allow suit engineers to parametrically generate body shapes in strategically targeted anthropometry dimensions and shoulder poses. This would also enable virtual fit assessments, with which the contact volume and clearance between the suit and body surface can be predictively quantified at reduced time and cost.